of the commencement of the experiment. I can only attribute this immunity to a very high degree of natural resistance which at times is met with in all experimental animals, and which we are compelled to allow for.

Eighteen animals were born during the course of the experiment, at intervals of 4, 5, 9, and 13 weeks, all of whose parents subsequently were found to be tuberculous. These were killed and examined at intervals, and in not one of them was there evidence of tuberculosis. It would therefore be not unreasonable to suppose that, although desiccation for a period of fourteen days proved insufficient to destroy, under these conditions, the virulence of the sputum, yet this was accomplished at some point between this and four weeks. What this point is, a further experiment on similar lines when sufficient sunlight is available, will be necessary to elucidate. I propose to carry this out in the early summer of next year.

"Effect of Exposure to Liquid Air upon the Vitality and Virulence of the Bacillus Tuberculosis." By H. SWITHINBANK. Communicated by Sir JAMES CRICHTON BROWNE, F.R.S. Received June 11,—Read June 20, 1901.

A series of experiments carried out early in the year 1900 with the object of testing the effect of the temperature of liquid air upon the vitality and virulence of the bacillus tuberculosis produced results which, although in complete accord as far as the question of vitality was concerned with those arrived at by Professor Macfadyen in the carefully planned experiments reported to the Royal Society on the 1st February and the 5th April, 1900, raised some doubt in my mind as to whether the abnormally low temperature, continued for a lengthened period, might not have some modifying effect upon the virulence of the organism. I decided therefore, in the month of January of this year, to put the question to the test of an experiment which I hoped would be conclusive.

The questions to be solved appeared to me to be—

1. Whether exposure for varying periods to the temperature of liquid air had any effect upon the vitality of the bacillus tuberculosis.
2. Whether such exposure in any way modified its virulence.
3. Whether time was a factor in the question.
4. Whether, as is the case at the higher end of the thermometric scale, successive alternations of temperature had any special effect.
5. Whether actual contact* with liquid air, if obtainable, produced any special results.

* The word "contact" is used throughout, but it is doubtful whether actual

The experiments, which were carried out in duplicate, lasted over a period of five months, and I am greatly indebted to Dr. Debrand, of the Pasteur Institute, not only for his general supervision of the experimental animals, but also for his kindness in making the autopsy of one complete series as a control.

A special strain of tubercle, isolated from a human cervical gland, was used for the purpose of inoculations. Sub-cultures of this were made upon potato, and the *raclage* from these was used throughout the whole series of experiments. This was enclosed in specially made tubes, and submitted to the influence of liquid air as follows* :—

Tubes A. Six hours continuous exposure to liquid air, without contact.

Tubes B. Twelve hours' exposure, without contact.

Tubes C. Twenty-four hours' exposure, without contact.

Tubes D. Twenty-four hours' exposure *with contact*, the tubes remaining filled with liquid air during the whole period.

Tubes E. Forty-eight hours' exposure, without contact.

Tubes F. One hundred and forty-four hours' exposure, without contact.

Tubes G. One week's exposure, without contact.

Tubes H. Six weeks' exposure, without contact.

Tubes K. Six weeks' exposure *with contact*, the tubes remaining filled with liquid air duriug the whole period.

To test the question of successive alternations of temperature :—

Tubes L. Six alternate exposures of one hour each during twelve hours to the temperature of liquid air and that of 15° C.

Tubes M. Three alternate exposures as above, followed by six hours continuous exposure to liquid air.

Tubes O. Controls.

The effect of the above treatment, judged by the result of the subcutaneous inoculation of the guinea-pig with an emulsion made from the contents of one of each series of the above tubes, will be shown by the following table. Thirty animals in all were inoculated, and $\frac{1}{2}$ c.c. of the emulsion was used in each case.

The question of vitality was tested by making sub-cultures from the tubes after exposure. With the exception of those tubes exposed to alternations of temperature, no difficulty was found in obtaining a luxuriant growth.

contact is possible. Given that a cell contains a large proportion of water, it is questionable whether the admission of liquid air to the tube containing the organisms would not give rise to the immediate formation around each individual cell of a thin coating of ice which would effectually protect the cell contents from any specific action the liquid air might possibly have upon them.

* The temperature of liquid air may be taken at −193° C., the actual temperature to which the organisms were exposed as −186° C.

Results of Subcutaneous Inoculation into the Guinea-pig of $\frac{1}{2}$ c.c. of an Emulsion in Broth of Contents of Tubes treated as above.

Tubes.	Treatment.	Animal died or killed.	After	Precis of *post-mortem* results.
A.	Six hours without contact	killed	100 days	Tubercular. Deep inguinal glands much enlarged and caseous. Liver enormously enlarged and studded with well-marked tubercles. Spleen much enlarged and crowded with tubercle. Peri-bronchial glands enlarged and calcareous. Mesenteric glands enlarged, and in some cases caseating. Tubercle bacilli found.
B.	Twelve hours without contact	killed	100 days	Tubercular. Glands of left inguinal region much enlarged and filled with caseous matter. Liver congested and permeated throughout with minute tubercles. Spleen ditto. Rare tubercles in lung structure. Peri-bronchial glands enlarged, hard, and in some cases caseating. Tubercle bacilli found.
C.	Twenty-four hours without contact	died	95 days	Tubercular. Deep inguinal glands enormously enlarged and caseous. Liver hypertrophied and full of tubercle. Spleen enormously enlarged and crowded with tubercles. Lungs a mass of minute tubercles. Tubercle bacilli found.
D.	Twenty-four hours *with contact*	killed	100 days	Tubercular. In left inguinal region an enlarged gland the size of a pea, hard and filled with caseous matter. Retro-peritoneal glands enlarged and caseous. Liver studded with tubercles. Gland at hilus of liver the size of small haricot and filled with cheesy pus. Spleen of normal size, but studded with minute tubercles. Peri-bronchial glands enlarged. Lungs studded with minute tubercles. Tubercle bacilli found.
E.	Forty-eight hours without contact	killed	100 days	Tubercular. Subcutaneous abscess at seat of inoculation. Inguinal glands slightly enlarged. Liver congested, patchy, and crowded with tubercle. Spleen permeated with minute tubercles. Caseating nodule on hilus of liver. Lungs covered with tuberculous patches. Large caseating nodule on superior surface of thorax. Peri-bronchial glands enlarged and caseating. Tubercle bacilli found.
F.	144 hours	died	78 days	Tubercular. Inguinal glands enormously enlarged and caseating. Liver

Tubes.	Treatment.	Animal died or killed.	After	Precis of *post-mortem* results.
				studded throughout with innumerable tubercles. Spleen enormous, and crammed with tubercle bacilli. Lungs one mass of tubercle.
G.	One week without contact	died	97 days	Tubercular. Much emaciated. Group of hard calcareous glands in right inguinal region. Ditto in left. Retro-peritoneal glands enlarged, hard, and calcareous. Liver studded with minute tubercles. Lungs a mass of miliary tubercle. Peri-bronchial glands much enlarged. Mesenteric glands enlarged and caseating. Tubercle bacilli found.
H.	Forty-two days without contact	died	94 days	Tubercular.* Inguinal glands enlarged, hard and calcareous. Retro-peritoneal glands ditto. Liver much enlarged and markedly tuberculous. Spleen enormously enlarged and crowded with tubercles the size of a millet seed. Lungs crowded with tubercles ranging in size from that of a small pin's head to that of a mustard seed. In submaxillary region a group of six enlarged glands the size of a haricot, together with several smaller ones, all hard and calcareous. Mesenteric glands enlarged, but not so seriously affected as other organs. Tubercle bacilli found.
K.	Forty-two days *with contact*	killed	94 days	Tubercular.* At seat of inoculation a large caseating nodule the size of a haricot. Liver enormously enlarged, friable, and permeated throughout with minute tubercles. Spleen much enlarged and crammed with minute tubercles. Lungs crowded with tubercles ranging in size from that of a millet seed to that of a grain of rice. Peri-bronchial glands enlarged and caseating. Mesenteric glands but slightly affected. Tubercle bacilli found.
L.	Alternate exposure as above to room temperature and extreme cold	killed	100 days	Animal very well nourished and in excellent condition. A small calcareous nodule at seat of inoculation. Spleen slightly enlarged. A few minute tubercles in lung structure, but rare. Peri-bronchial glands slightly enlarged. Tubercle bacilli found, but with difficulty.

* The emulsion used for inoculation of these two animals was of much greater density than that employed in other cases.

Tubes.	Treatment.	Animal died or killed.	After	Precis of *post-mortem* results.
M.	Alternate exposure as above to room temperature and extreme cold	killed	100 days	No evidence of tubercle found in animal of English series. In that of French series a few minute tubercles were found in lung structure.

The control animals (inoculated from Tubes O) died after a period of 42, 54, 56, and 63 days, respectively, the autopsy of these showing marked tuberculosis, affecting almost every organ of the body. The series of animals, of which the autopsy was made at the Pasteur Institute, gave results in every way corroborative of those detailed above.

It should be noted: 1. That the control animals succumbed to the disease at a much earlier date than those inoculated with the exposed material, seven of these latter being still living on the 100th day from the commencement of the experiment. The sole exception to this is guinea-pig 13 G, inoculated with material exposed for one week, which died on the thirty-third day.

2. That the time of exposure appeared to make no difference, the animals inoculated with material exposed for forty-two days showing at death tuberculous lesions as pronounced as those in which the material was exposed for the shortest period.

3. That no difference could be traced in the virulence of the material exposed to contact with liquid air.

4. That in animals inoculated with material which had been subjected to alternate exposures, it was difficult to find evidence of tubercle. It was only after very careful search that some small tuberculous lesions could be discovered.

To sum up the results of the experiment, it would appear then—

1. That simple exposure to the temperature of liquid air has little or no effect upon the bacillus tuberculosis as far as vitality is concerned.

2. That its virulence is to some degree modified, but not destroyed, by such exposure, even if it be continued for a lengthened period.

3. That length of exposure is not a factor in the question.

4. That actual immersion in liquid air has no special effect upon the organism, nor does it produce results in any way differing from simple exposure to the temperature obtained by it.

5. That successive alternations of extreme cold and normal tem-

perature have a decidedly destructive effect upon the vitality and virulence of the organism.

I am very greatly indebted to Professor Dewar, F.R.S., not only for a constant supply of liquid air, but also for many valuable suggestions given me during the course of the experiment, and my cordial thanks are due to Dr. Roux and the officials of the Pasteur Institute for the facilities given me at that Institution for carrying out the necessary inoculations.

"On the Behaviour of Oxy-hæmoglobin, Carbonic-oxide-hæmoglobin, Methæmoglobin, and certain of their Derivatives, in the Magnetic Field, with a Preliminary Note on the Electrolysis of the Hæmoglobin Compounds." By ARTHUR GAMGEE, M.D., F.R.S., Emeritus Professor of Physiology in the Owens College, Victoria University. Received and Read, June 20, 1901.

1. *The Observations of Faraday and Plücker on the Diamagnetic Properties of the Blood.*

In the course of his investigations on magnetism and diamagnetism, read before the Royal Society in the year 1845, Faraday* found that, notwithstanding the iron which its colouring matter contains, the blood is a diamagnetic liquid. "I was much impressed," he remarked, "by the fact that blood was not magnetic, nor any of the specimens tried of red muscular fibre of beef or mutton. This was the more striking, because, as will be seen hereafter, iron is *always* and in almost all states magnetic. But in respect to this point it may be observed that the ordinary magnetic property of matter and this new property are in their efforts opposed to each other; and that when this property is strong it may overcome a very slight degree of ordinary magnetic force, just as also a certain amount of magnetic property may oppose and effectually hide the presence of this force." † Faraday further found the blood to behave like all the constituent tissues of animal bodies which he investigated, and was led to state that "if a man could be suspended with sufficient delicacy, after the manner of Dufay, and placed in the magnetic field, he would point equatorially;

* "On New Magnetic Actions and on the Magnetic Condition of all Matter," 'Phil. Trans.,' 1846, part 1.

† Faraday's 'Experimental Researches in Electricity,' vol. 3 (1845), p. 36, para. 2285.